CAMBRIDGE TECHNICALS

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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 2 Summer 2024 series

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Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

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Unit 2 series overview

Unit 2 Science for Engineering is an externally assessed unit of study which is a mandatory part of all the routes through the Cambridge Technical Level 3 Engineering qualifications.

It consists of six questions covering all the learning objectives of the specification using a range of contexts. Some of the questions included some context, such as the temperature sensor circuit used to cover parts of Learning Objective 3 and the airship for Learning Objective 6.

Generally, candidates did well on Question 1 covering SI units and measurements. Candidates also fared better on Question 2, covering some aspects of mechanics, and Question 4, on materials. Many found Question 3 on electrical circuits more difficult.

Many of the questions require numerical calculations. Where an equation needs to be recalled, candidates should be encouraged to write the equation down as a first step. Then it is good practice to identify the quantities needed before substituting them into the equation before calculating the response, and it was good to see several candidates do this. This is particularly important for multi-stage calculations such as that in Question 5(d).

Candidates also need to pay particular attention to the units of the data and if necessary, carry out any unit conversions prior to finalising their response.

In questions where candidates are asked to explain scientific terms or phenomena, they should try to use scientific terminology correctly and structure their response in a logical format.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• read the question carefully and ensured that they answered what was being asked • laid out calculation clearly • used scientific terminology correctly.	• showed unfamiliarity with the equations in the formula booklet • confused SI base units with SI derived units • paid little attention to the units quantities were given in and the units shown on the answer line.

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Question 1 (a)

1

(a) Which of these are SI base units?

Tick (✓) **three** boxes.

Ampere	☐
Coulomb	☐
Hour	☐
Metre	☐
Second	☐
Volt	☐

[3]

Many candidates correctly identified the three SI base units; a common misconception was to think that Coulomb was the electrical SI base unit, rather than Ampere.

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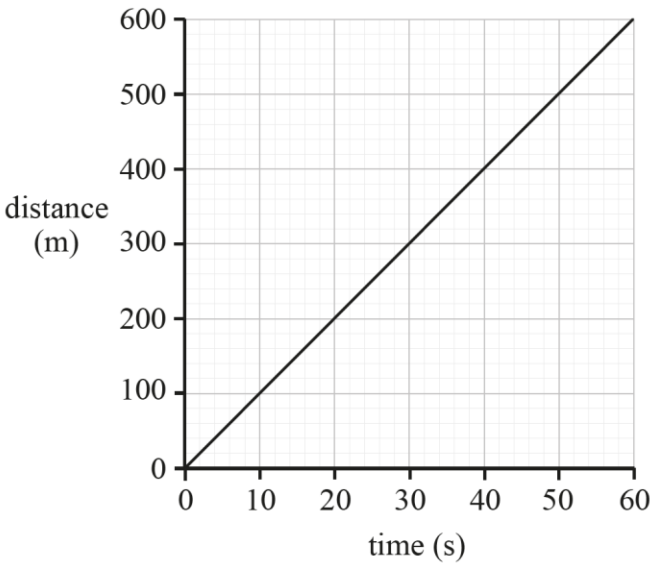
Question 2 (a)

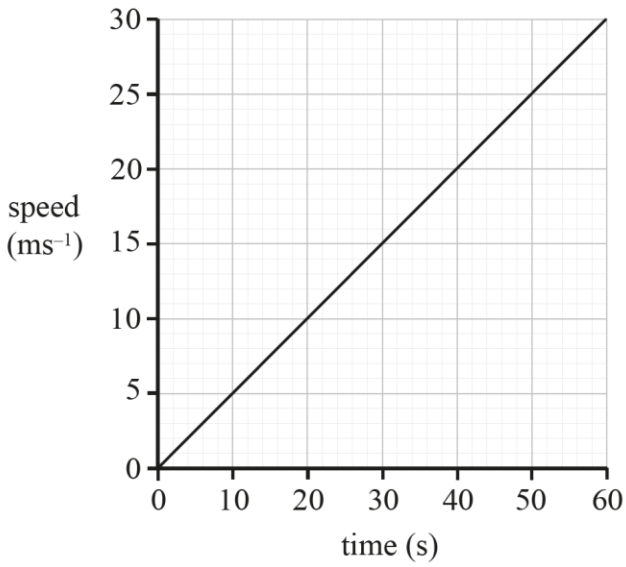
2

(a) Graphs **X** and **Y** below represent two different car journeys in different ways.

Graph **X**



Graph **Y**



The table below contains statements about the two car journeys.

The statements can be true for one, both or neither journey.

Tick (✓) **one** box on each row.

Statement	**Graph X only**	**Graph Y only**	**Both graphs**	**Neither graph**
The car is travelling at constant speed.				
20 s after the journey started, the speed is 10 ms^{-1}.				
The car slows down during the journey.				
40 s after the journey started, the distance travelled is 400 m.				

[4]

This question tested understanding of motion graphs and many candidates got the first three correct, but didn't check the distance travelled (the area under the velocity-time graph) was also 400m, and ticked the Graph X only box for that one.

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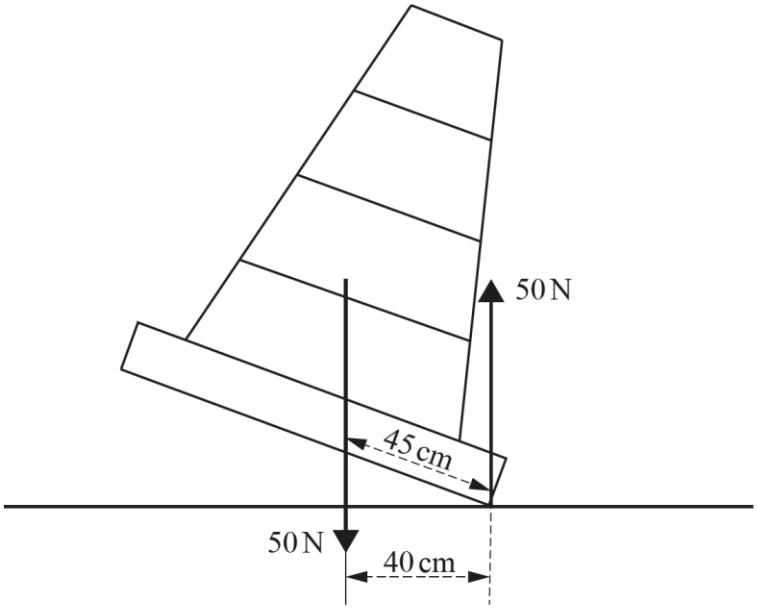
Question 2 (b) (i) and (ii)

(b) A traffic cone is tipped to one side as shown in the diagram, and then released.



(i) Explain how the diagram shows that a couple is acting.

.....

.....

..... **[2]**

(ii) Calculate the torque of the couple acting in the diagram above.

Give your answer in Nm.

Use the equation:

torque of a couple = force × perpendicular distance between the forces.

torque = ... Nm **[2]**

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Many candidates did mention two forces here, but either forgot to state that they were 'equal' or used the term 'different' instead of 'opposite' in direction. Most candidates did not explicitly state that they were acting at different points or that they were parallel.

Misconception

Some candidates thought that the cone, in its tipped position, was in equilibrium.

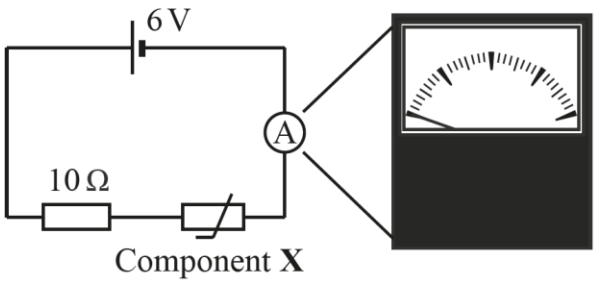
If a couple is acting, then the cone is not at equilibrium. In this case the forces are equal and opposite, but as they don't act on the same point, the cone is not at equilibrium.

Most candidates substituted a value of force and a value of distance into the given equation. Common errors were to double the force, use 45cm instead of 40cm as the perpendicular distance. The answer line indicated that the answer should be given in the units of Nm, but many candidates did not convert the distance from cm into m.

Question 3 (a)

3 The diagram shows the circuit for a simple temperature sensor.

The meter has no values marked on the scale.



(a) To use the sensor, values need to be written on the scale of the meter.

State the measurement term that best describes this process.

..... **[1]**

Many candidates didn't answer the question about the process and gave answers such as ammeter.

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Question 3 (b) (i)

(b)

(i) State the name of component **X**.

..... **[1]**

Many candidates correctly gave the name of the component. Common errors included variable resistor and LDR.

Question 3 (b) (ii)

(ii) On the axes below, sketch the variation of resistance with temperature for component **X**.

[2]

Many candidates were not able to identify the circuit symbol as a thermistor and common incorrect answers included variable resistor and resistor.

Only a few candidates recalled that the resistance of a (ntc) thermistor decreases with increasing temperature, and many drew a straight upwards sloping line on the graph. Very few candidates showed the correct curvature for the relationship.

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Question 3 (c)

The sensor circuit is placed first in a fridge known to be at 0 °C and then in steam at 100 °C to mark the scale.

(c) At 0 °C, component **X** has resistance 40 Ω.

Calculate the current in the circuit.

current = ... A **[3]**

While most candidates were able to use Ohm's Law equation, most of them did not use the value for the total resistance in the circuit. Candidate must look back at the circuit diagram to note that component X is in series with a fixed resistor so the total resistance is 50 Ω.

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Question 3 (d) (i)

(d) The 10 Ω resistor is made from a 0.40 m length of wire.

(i) The resistivity of the wire material is 1.5×10^{-6} Ωm.

Calculate the cross-sectional area of the wire.

cross-sectional area = ... m^2 **[3]**

Many candidates used the correct equation, but some were unable to rearrange it to find the area. Some candidates mistook the symbol '*l*' (length) for '*I*' (current), and then used the value of current found in the previous part of the question. Care needs to be taken when writing out equations and subsequent working.

Question 3 (d) (ii)

(ii) Explain why the 10 Ω resistor must be made from a material that has a low temperature coefficient of resistance.

.....

.....

.....

.....

..... **[2]**

Many candidates did not show an understanding of the term 'temperature coefficient of resistivity'. Several responses indicated that they thought it was resistivity – for example, a low temperature coefficient meant that the resistance was low. Others interpreted it as having some relationship with how hot the component would become and suggested that the component get too hot and burn out or not be able to withstand high temperatures. Some of those who did understand the concept of temperature coefficient did not appreciate that if the fixed resistor changed it would then affect the reading of temperature from the sensing circuit.

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Exemplar 1

to make sure it doesn't effect any of the results as there needs to be a constant resistance other doesn't change when in high temperatures

In Exemplar 1, the candidate appreciates the context for the circuit; it is being used as a temperature sensor, as well as showing understanding of what temperature coefficient of resistance means. The resistor in the circuit needs to be constant otherwise it will affect the results or reading of temperature. Then the candidate explains that if the resistor did not have low temperature coefficient of resistance, its resistance would change when the temperature changed.

Question 4 (b)

(b) Complete the sentence below.

Choose **two** words/phrases from the following list.

elastic limit **force** **strain** **stress** **ultimate tensile stress** **yield point**

A brittle material can only withstand a relatively small .....

before it reaches its ..... .

[2]

Many candidates recognised that brittle failure is about snapping (or suffering a force that takes it beyond its UTS) but, failed to recognise that it is only a relatively small extension (or strain) before snapping that makes it appear brittle (and not ductile). Many of them managed to identify the force-extension graph for a brittle material in part (a) without being able to explain this behaviour in words.

Question 4 (c) (i)

(c)

(i) State the SI derived unit for stress.

..... **[1]**

Many candidates answered with the correct response here (Pascal) but many tried to convert the derived unit into SI base units, which was not what the question asked.

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Question 4 (d) (i)

(d) The properties of materials are affected by the type and arrangement of the atoms they are made from.

(i) Explain the term **equilibrium separation** of the atoms in a material.

.....

.....

..... **[2]**

Most candidates did not explain 'equilibrium separation' well. Many of them suggested that it was when atoms separated equally and some candidates just didn't answer the question, but made another comment about how atoms behave under stress. Some candidates did correctly mention the distance between atoms, but did not describe equilibrium in terms of the forces acing on the atom.

Assessment for learning

When a question asks a candidate to explain a scientific term, it is better to try to use alternative words, rather than the exact words in the question.

This question is directly testing specification point 4.4.

Question 4 (d) (ii)

(ii) The equilibrium separation and atomic mass affect the material's density.

A cube of aluminium 15 cm on each side has mass 9.1 kg.

Calculate the density of aluminium in kg m^{-3}.

density = ... kg m^{-3} **[3]**

Many candidates were able to select and use the correct equation and calculate density. Some made no attempt to calculate the volume and some just used the cross-sectional area instead of volume, but a common error was to use the volume in cm^3; not converting to m^3, before substituting into the equation.

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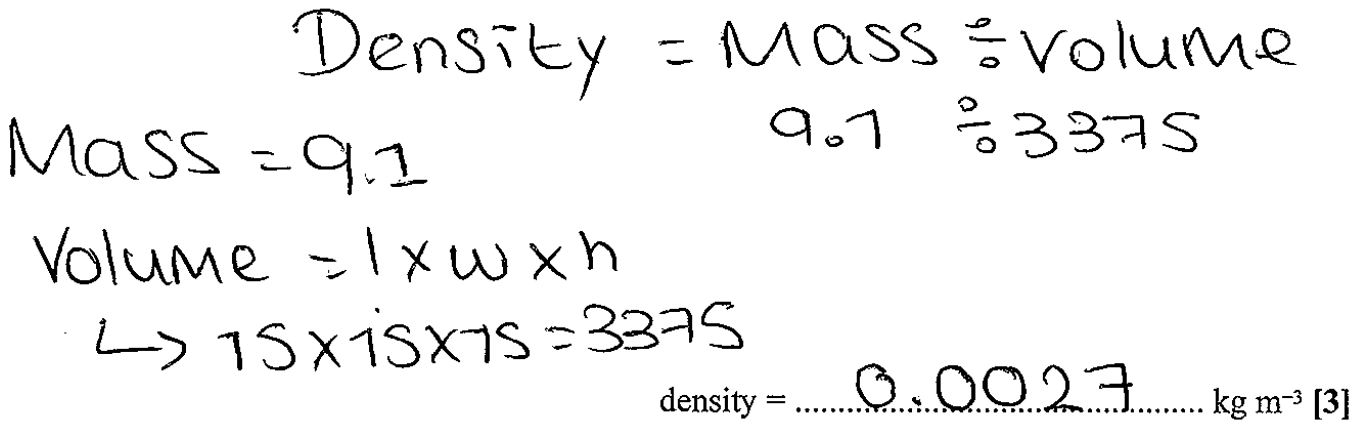
Exemplar 2



In Exemplar 2, the candidate has laid out their working well. They start by writing the equation down clearly. The volume of the cube has been calculated but left in cm^3, so the final value has a power of ten (POT) error.

Assessment for learning

It is usually easier to convert length to SI units before finding area or volume.

15 cm = 0.15 m, and it is straightforward to then calculate volume = $0.15^3 = 3.375 \times 10^{-3}$ m^3.

$(15\ cm)^3 = 3375\ cm^3$, but the conversion factor from cm^3 to m^3 is more complicated to work out as you need to divide by 100^3. $3375 \div 100^3 = 3.375 \times 10^{-3}$ m^3.

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Question 5 (b)

(b) The table shows five measurements of pressure in a compressible fluid.

The mean of the measurements is 100 kPa.

Calculate the standard deviation of the measurements.

You can use the two empty rows to help with your calculations.

	1	**2**	**3**	**4**	**5**
Pressure reading/kPa	101	104	98	99	98

standard deviation = ... **[3]**

There is an overlap with Unit 1 here so many candidates are familiar with calculating standard deviation and many of them are able to use scientific calculators to do so. Some candidates did show working and many got the answer correct. Some copied down an equation from the formula booklet but didn't show any understanding of how to use the equation. Some calculated a mean which was already given to them in the question. Some just used one piece of data; finding its difference from the mean and squaring it, rather than working out the sum of the squares of the differences from the mean for all the data.

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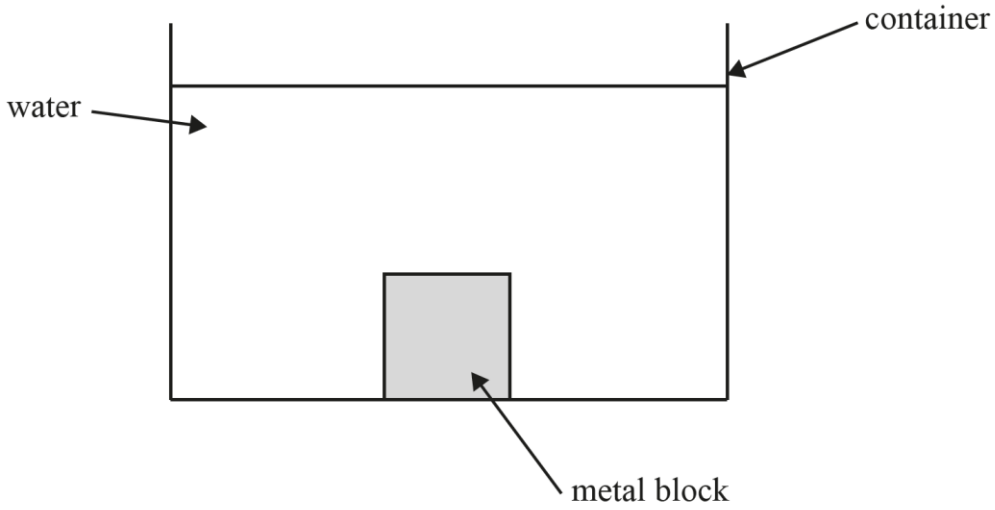
Question 5 (c)

(c) The diagram shows a cubic metal block submerged in water.



Draw arrows on each side of the block to show the relative size and direction of the water pressure acting on the block.

[4]

Most candidates gained some credit here for drawing some arrows in the correct direction, towards the block at right angles to the surface. Often there was only one arrow on each side of the block so the candidate's response did not show that the pressure across the whole of the top surface was equal and the pressure acting on the sides increased with depth.

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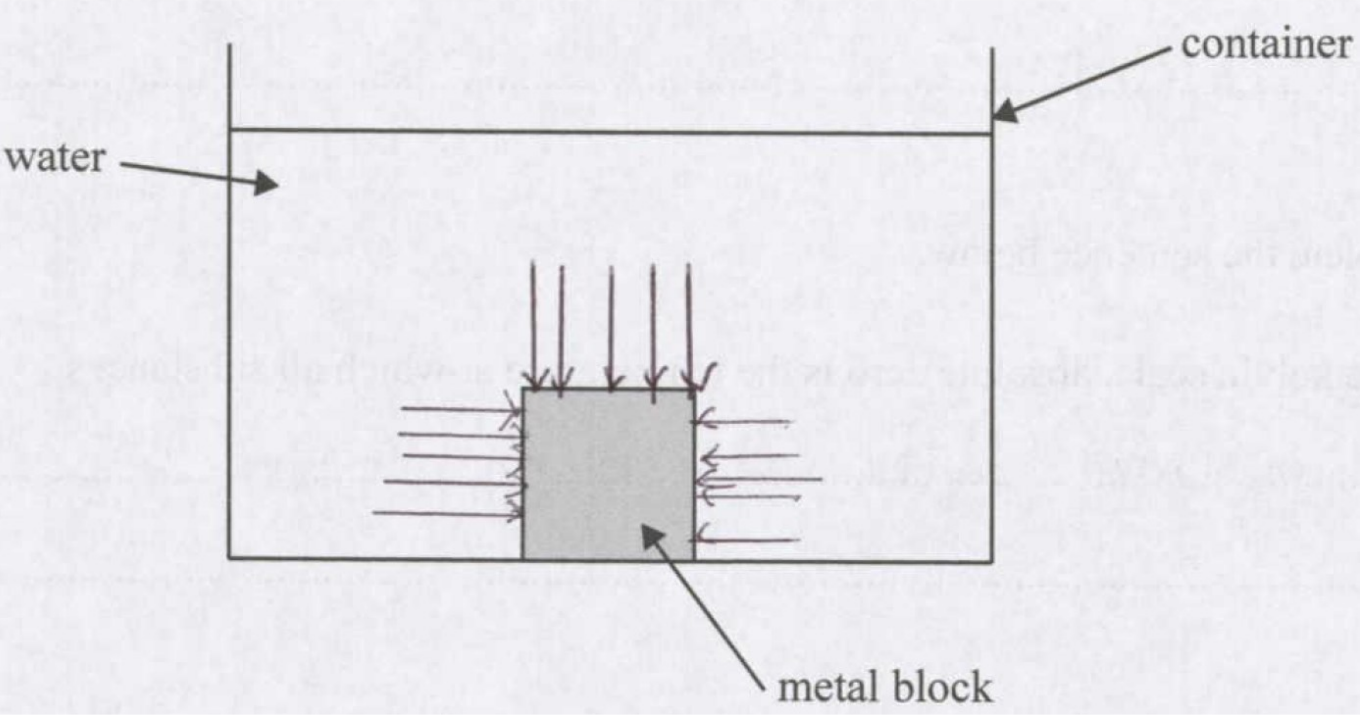
Exemplar 3



In Exemplar 3, the candidate has drawn a number of arrows depicting pressure acting on each side of the cube. The arrows on the top do look approximately all the same length, but are not evenly distributed. The arrows on the left side of the block do roughly look like they are increasing in length as the depth of water increases, but the arrows on the right side are a bit random in length. If the right side looked more similar to the left side this would have gained more credit.

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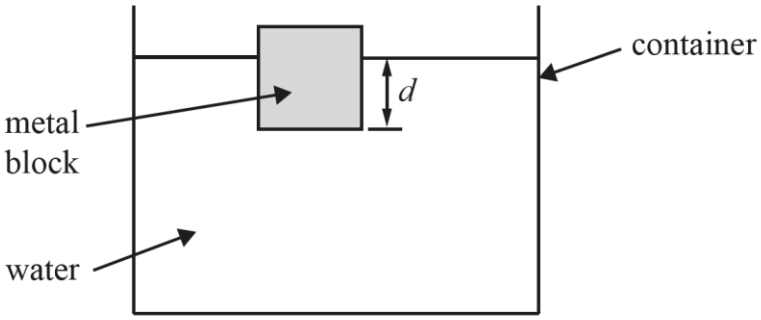
Question 5 (d)

(d) A different cubic metal block of mass 86 kg floats in the water as shown in the diagram.



The cross-sectional area of the block is 0.20 m^2.

The density of water is 1000 kg m^{-3}.

The block is submerged to a depth, d m.

Use Archimedes' principle to calculate the value of d.

d = ... m **[3]**

Many candidates tackled this well with clear working. Others did get to the correct final answer but did not show working. Some candidates showed a circular argument, starting by finding the square root of the area to find the side length of the cube and hence the volume of the solid cube, and the density of the cube, rather than realising that they needed to find the volume of liquid which had the same mass as the cube.

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Question 6 (a) (ii)

(ii) Complete the sentence below.

On the kelvin scale, absolute zero is the temperature at which all substances have .....

..... **[2]**

This question was not well answered. A common error was just to say that the particles had no kinetic energy and did not refer to internal energy at all.

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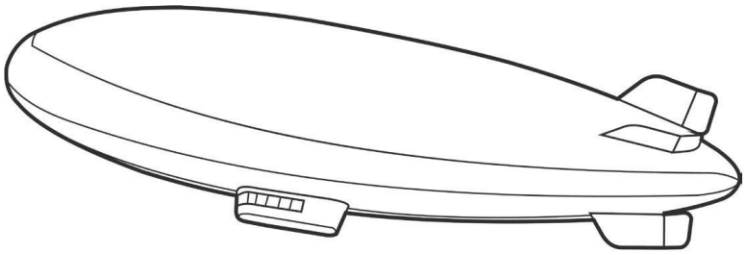
Question 6 (b)

Giant airships have been proposed as a way of carrying cargos too heavy for drones or helicopters to inaccessible areas where planes cannot land.

(b) A rigid airship has a fixed volume of 3000 m^3 and contains helium at a pressure of 110 kPa when the outside temperature is 320 K.



Use the characteristic gas equation to calculate the mass of helium in the airship.

The specific gas constant for helium is 2080 $JK^{-1}kg^{-1}$.

Give your answer to **3** significant figures.

mass = ... kg **[4]**

This question discriminated well as some candidates didn't read the part stating that the final answer should be given to 3 significant figures – and there were some candidates who didn't understand the meaning of 3 significant figures.

There was a mixture between candidates who laid out their working clearly and those who did not, and there were many candidates who did not convert 110kPa to 100000 Pa and their final answer had a power of ten (POT) error.

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Question 6 (c)

(c) When the airship is hovering at an altitude of 1000 m, the temperature is 280 K.

Complete the calculation below using the Pressure law to find the new pressure, p_2.

$$\frac{\square}{320} = \frac{p_2}{\square}$$

new pressure p_2 = ... kPa **[3]**

Poor algebra let down many candidates here and some decided to use the altitude (1000 m) instead of looking back at the earlier part of the question to find the value of p_1 = 110 Kpa. A few candidates decided to try, unnecessarily, to convert the temperature in Kelvin to degrees Celsius. The boxes given in the answer space were there to guide candidates in the right direction but many candidate did not use this structure.

Question 6 (d)

(d) Although the airship is rigid, the outer skin does deform slightly in flight.

The skin deforms elastically.

Explain the difference between elastic and plastic deformation of a material.

.....

.....

..... **[2]**

The majority of candidates explained that elastic deformation was reversible in several different ways and/or that plastic deformation was permanent.

The main reason for not gaining full credit here was to omit to say that the difference in the two types of behaviour was seen when the force or load was removed.

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Question 6(b) Image of airship: Shutterstock Credit: AriffAmin Illustration

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